ANSWERS: Crystal ball questions on Describing and Explaining shapes of molecules

1) The central atom in **H_2O** has four regions of electron density around it. Two of these are bonding and two are non bonding. These four regions repel each other as far apart as possible. The regions of electron density are arranged as far apart as possible from each other in a tetrahedral position. The name for this shape is v-shaped as there are 2 bonded pairs and 2 lone pairs around the central atom with a bond angle of less than 109.5 ^{o} due to repulsion caused by the 2 lone pair of electrons.

The central atom in **OF_2** also has four regions of electron density around it. Two of these are bonding and two are non bonding. These four regions repel each other as far apart as possible. The regions of electron density are arranged as far apart as possible from each other in a tetrahedral position. The name for this shape is v-shaped as there are 2 bonded pairs and 2 lone pairs around the central atom with and the bond angle is less than 109 $^{o.}$ The reason that the bond angle is smaller than in water is because the lone pairs of electrons on the F atoms reduce the angle to even smaller than that of H_2O.

2) NH_3 and PH_3

The central atom of N in NH_3 and central atom of P in PH_3 both have four regions of electron density around them. Three of these are bonding and one is non bonding. These four regions repel each other as far apart as possible. The regions of electron density are arranged as far apart as possible from each other in a tetrahedral position. The name for the shapes of both of these molecules is trigonal pyramidal as there are 3 bonded pairs and 1 lone pairs around the central atom.

The bond angle for NH_3 is less than 109.5 ^{o} but the bond angle for PH_3 is even more so, perhaps less than 109 ^{o}.

The nitrogen atom is more electronegative that the P atom and so the electron density of nitrogen's bonding pairs will be held closer to the nitrogen. If the bonding electrons are closer to the central atom they will exert a greater repulsive effect on each other. The bonding pair - bonding pair repulsions are larger in NH_3 than in PH_3.
In PH_3 the bonding pair electrons are relatively far from the phosphorus atom as the phosporous atoms is not very electronegative) meaning that the electrons cannot repel each other very effectively.

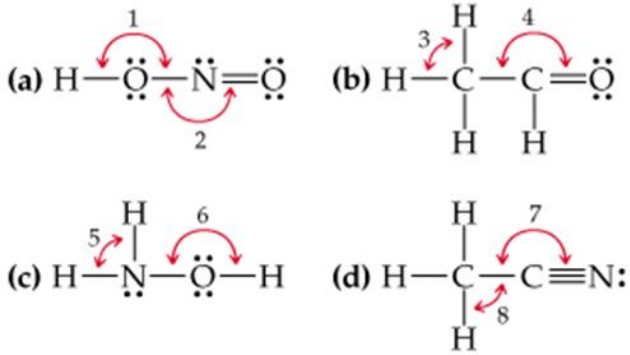
3) H_2CO and BCl_3

The central atom of C in H_2CO and central atom of B in BCl_3 both have three regions of electron density around them. Three of these are bonding and none are non bonding. These three regions repel each other as far apart as possible. The regions of electron density are arranged as far apart as possible from each other in a trigonal planar position.
So, both molecules have the same shape of trigonal planar and the same bond angle of 120 $^{o.}$

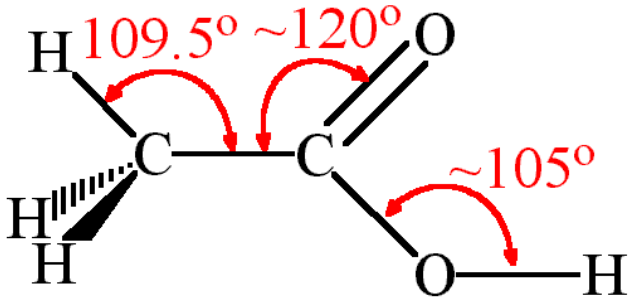
4) All 3 molecules (ethane, ethene and ethyne) have an **overall shape of linear** with a bond angle of **180 ^{o}**
Other angles within the 3 different molecules vary.
In ethane, there are 4 regions of electron density around the C atoms, these four regions repel each other as far apart as possible, the angles are 109.5 ^{o} with a tetrahedral shape, as each C atom is bonded to 4 other atoms, with no lone pairs.
In ethene, there are 3 regions of electron density around the C atoms, these three regions repel each other as far apart as possible, the angles are 120 ^{o} with a trigonal planar shape as each C atom is bonded to 3 other atoms, with no lone pairs.
In ethyne, there are 2 regions of electron density around the C atoms, these two regions repel each other as far apart as possible, the angles are 180 ^{o} with a linear shape as there each C atom is bonded to 2 other atoms, with no lone pairs.

5)

1) there are 4 regions of electron density around the central O atom, these four regions repel each other as far apart as possible, there are 2 lone pairs and 2 bonded pairs around the O atom so overall it is a bent or v-shaped with an angle of less than 109.5 °
2) there are 3 regions of electron density around the central N atom, but 2 are bonded and 1 is a lone pair, these three regions repel each other as far apart as possible, a lone pair exerts a greater repulsion than a bonded pair so the angle of 120 decreases slightly to 118° with a bent or v-shape
3) there are 4 regions of electron density around the central C atom, these four regions repel each other as far apart as possible, there are 4 bonding pairs so overall a tetrahedral shape with bond angle of 109.5 °
4) there are 3 regions of electron density around the central C atom, these three regions repel each other as far apart as possible, there are 3 bonding pairs and no lone pairs so the bond shape is trigonal planar with a bond angle of 120°
5) there are 4 regions of electron density around the central N atom, 3 are bonding pairs and 1 is a lone pair, these 4 regions will repel each other as far as possible, so there is a trigonal pyramid shape with a bond angle of less than 109.5°
6) there are 4 regions of electron density around the central O atom, 2 are bonding pairs and 2 are a lone pair, these 4 regions will repel each other as far as possible to give a bent or v-shaped with a bond angle of less than 109.5 °
7) there are 2 regions of electron density around the central C atom, 2 are bonding pairs and there are no lone pairs, these 2 regions will repel each other as far as possible to give a linear shape with a bond angle of 180°
8) there are 4 regions of electron density around the central C atom, all 4 are bonding pairs, these 4 regions will repel each other as far as possible to give a tetrahedral shape with a bond angle of 109.5°



6)

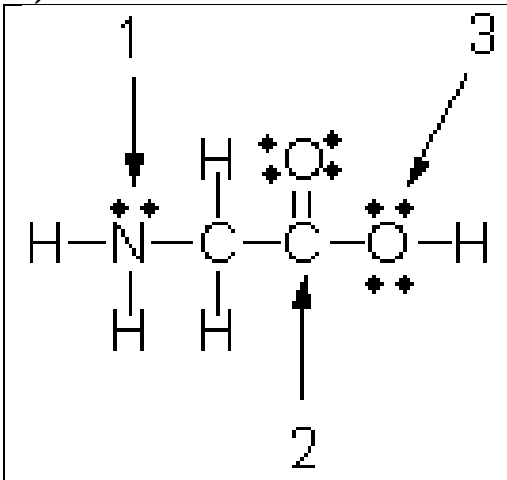


angle A: 109.5° around the central C atom as there are 4 regions of electron density with 4 bonding pairs and no lone pairs, these four regions repel each other as far apart as possible, tetrahedral shape

angle B: trigonal planar as there are 3 regions of electron density around the central C atom, 3 are bonding pairs with no lone pairs, these 3 regions repel each other as far apart as possible to give a bond angle of 120°

angle C: bent or v-shaped as there are 4 regions of electron density around the central atom, there are 2 lone pairs and 2 bonding pairs around the central O atom, these four regions repel each other as far apart as possible to give a bond angle of less than 109.5 °

7)

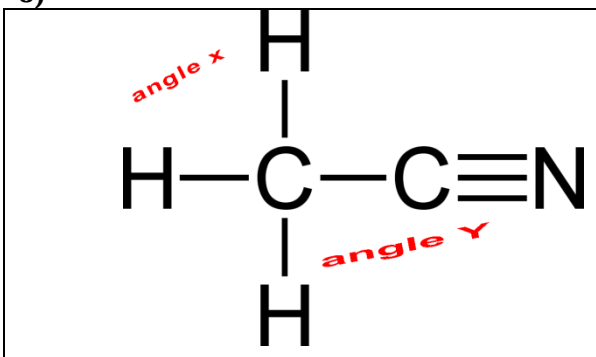


angle 1: angle of less than 109.5 ^{o} as there are 4 regions of electron density around the central N atom, but 3 are bonding and 1 is a lone pair, these 4 regions repel each other as far apart as possible to give an overall shape of trigonal pyramidal

angle 2: 3 regions of electron density around the central C atom, all 3 are bonding regions with no lone pairs, these 3 regions repel each other as far apart as possible to give a bond angle of 120° with a trigonal planar shape

angle 3: bent or v-shaped as there are 4 regions of electron density around the central O atom, 2 are lone pairs and 2 are bonding pairs, these 4 regions repel each other as far apart as possible to give an overall shape of bent or v-shaped with a bond angle of less than 109 ^{o}

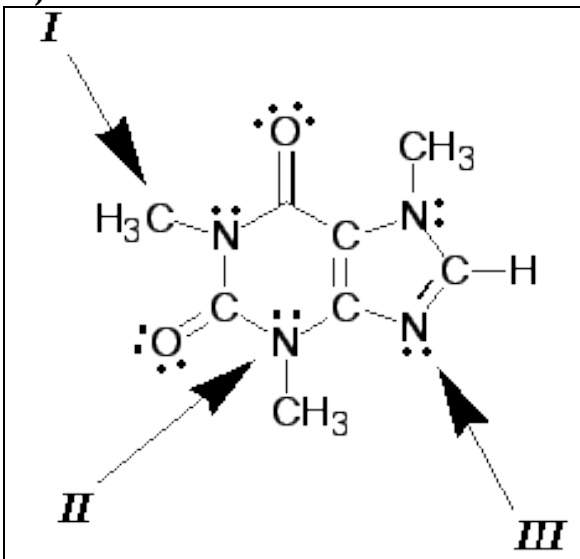
8)



angle X: 4 regions of electron density around the central C atom, of these 4 are bonding pairs and there are no lone pairs, these 4 regions repel each other as far apart as possible so overall the shape is tetrahedral with a bond angle of 109.5°

angle Y: 2 regions of electron density around the central C atom, 1 bonding pairs to another C atom and 3 bonding pairs (all together) to the N atom, these 2 regions repel each other as far apart as possible to give a linear shape with an angle of 180°

9)

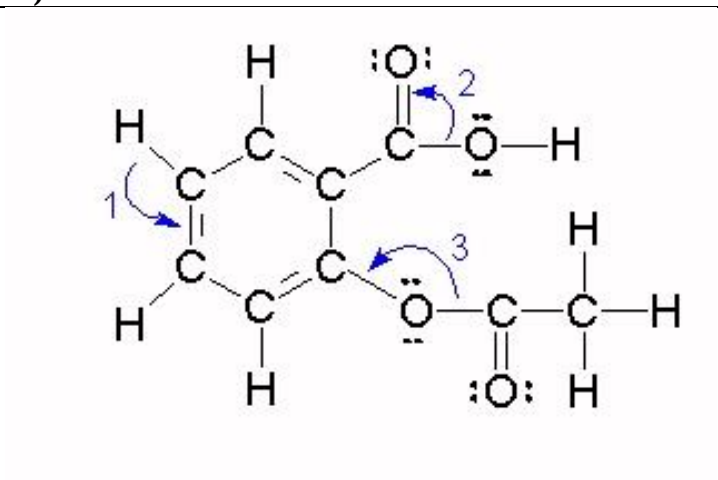


angle i: the central atom is the C atom, there are 4 regions of electron density around the central C atom, 4 bonding pairs and no lone pairs, these 4 regions repel each other as far apart as possible to give a tetrahedral shape with an angle of 109.5°

angle II: the central atom is the N atom, there are 4 regions of electron density around the central N atom, 3 bonding pairs and 1 pairs, these 4 regions repel each other as far apart as possible to give a trigonal pyramidal shape with an angle of less than 109.5°

angle iii: there are 3 regions of electron density around the central N atom, but 2 are bonded and 1 is a lone pair, these three regions repel each other as far apart as possible, a lone pair exerts a greater repulsion than a bonded pair so the angle of 120 for trigonal planar with 3 bonding pairs decreases slightly to less than 120° with a bent or v-shape due to the 2 bonding pairs and 1 lone pair.

10)



angle 1: the central atom is the C atom, there are 3 regions of electron density around the central C atom, 3 bonding pairs and no lone pairs, these 3 regions repel each other as far apart as possible to give a trigonal planar shape with an angle of 120°

angle 2: the central atom is the C atom, there are 3 regions of electron density around the central C atom, 3 bonding pairs and no lone pairs, these 3 regions repel each other as far apart as possible to give a trigonal planar shape with an angle of 120°

angle 3: bent or v-shaped as there are 4 regions of electron density around the central O atom, 2 are lone pairs and 2 are bonding pairs, these 4 regions repel each other as far apart as possible to give an overall shape of bent or v-shaped with a bond angle of less than 109.5°